

INCH-POUND

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SUPERSEDING

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MILITARY SPECIFICATION

CAPACITORS, FIXED, PLASTIC (OR METALLIZED PLASTIC) DIELECTRIC, DC OR DC-AC, IN NONMETAL CASES, ESTABLISHED RELIABILITY GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for plastic (or metallized plastic) dielectric, fixed capacitors, enclosed in nonmetal cases intended primarily, in view of the limited long term moisture resistant characteristics, for use in potted or encapsulated systems, in blocking, filter and by-pass applications (see 6.4). Capacitors covered by this specification have failure rates ranging from 1.0 percent to 0.001 percent per 1,000 hours (see 1.2.1.7). These failure rate levels are established at a 90 percent confidence level and maintained at a 10 percent producer's risk, and are based on life tests performed at +85°C. An acceleration factor of 5:1 has been used to relate life test data obtained at 125 percent, or 140 percent of rated voltage at +85°C to rated voltage at +85°C. The failure rate levels are based on catastrophic failures and failures occurring outside the degradation limits.

1.2 Classification. Capacitors covered by this specification shall be classified as indicated by style (see 1.2.1.1 and 3.1).

1.2.1 Part or Identifying Number (PIN). The term Part or Identifying Number (PIN) is equivalent to the term (part number, identification number, and type designator) which was previously used in this specification. A Parts Per Million (PPM) quality system is used for documenting and reporting the average outgoing quality of capacitors supplied to this specification. Statistical Process Control (SPC) techniques are required in the manufacturing process to minimize variation in production of capacitors supplied to the requirements of this specification. The PIN shall be in the following form, and as specified (see 3.1 and 3.26.1).

CFR02	A	M	C	682	J	M
Style (see 1.2.1.1)	Terminal (see 1.2.1.2)	Characteristic (see 1.2.1.3)	Rated voltage (see 1.2.1.4)	Capacitance (see 1.2.1.5)	Capacitance tolerance (see 1.2.1.6)	Failure rate level (see 1.2.1.7)

1.2.1.1 Style. The style is identified by the three-letter symbol "CFR" followed by a two-digit number; the letters identify established reliability, plastic dielectric fixed capacitors in nonmetal cases.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, U.S. Army Laboratory Command (LABCOM), ATTN: SLEET-R-S, Fort Monmouth, NJ 07703-5302, by using the Standardization Document Improvement Proposal (DD Form 142b) appearing at the end of this document or by letter.

AMSC N/A

ESD 5910

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

1.2.1.2 Terminal. The terminal is identified by a single letter as shown in table I.

TABLE I. Terminal.

Symbol	Terminal
A	Axial wire-lead
R	Radial wire-lead
L	Lugs

1.2.1.3 Characteristic. The characteristic is identified by a single letter as shown in table II.

TABLE II. Characteristic.

Symbol	Construction		Operating temperature range
	Dielectric material	Electrode	
K	Polypropylene	Foil	-55°C to +105°C
L	Polypropylene	Metallized polypropylene	-55°C to +105°C
M	Polyethylene terephthalate	Foil	-55°C to +85°C
N	Polyethylene terephthalate	Metallized polyethylene terephthalate	-55°C to +85°C
Q	Polycarbonate	Foil	-55°C to +125°C ^{1/}
R	Polycarbonate	Metallized polycarbonate	-55°C to +125°C ^{1/}
S	Poly-para-xylylene	Foil	-55°C to +125°C ^{1/}

^{1/} For operation at +125°C, characteristics Q, R, and S capacitors shall be voltage derated (see table III).

1.2.1.4 Rated voltage. The rated voltage is for operation at +85°C and is identified by a single symbol as shown in table III.

TABLE III. Voltage rating at +85°C. ^{1/}

Symbol	DC voltage rating
A	50
B	100
C	200
D	300
E	400
F	600
G	75
H	150
J	25
K	250
L	800

^{1/} Voltage derating at high ambient temperatures is dependent on the characteristic as follows: Characteristics M and N are rated for +85°C operating only. The +85°C rating of characteristic Q capacitors shall be derated by one-third for operation at +125°C. The +85°C ratings of characteristics R and S capacitors shall be derated by one-half for operation at +125°C.

1.2.1.5 Capacitance. The nominal capacitance value, expressed in picofarads (pF), is identified by a three-digit number; the first two digits represent significant figures and the last digit specifies the number of zeros to follow.

NOTE: Tabulated capacitance values expressed in microfarads (μ F) are given for information only (see 3.1).

1.2.1.6 Capacitance tolerance. The capacitance tolerance is identified by a single letter as shown in table IV.

TABLE IV. Capacitance tolerance.

Symbol	Capacitance tolerance
	Percent (\pm)
F	1
G	2
J	5
K	10
M	20

1.2.1.7 Failure rate level. The failure rate level (based on life test performed at +85°C) is identified by a single letter as shown in table V.

TABLE V. Failure rate level (established at a 90-percent confidence level).

Symbol	Failure rate level
	Percent/1,000 hours
M	1.0
P	0.1
R	0.01
S	0.001

2. APPLICABLE DOCUMENTS

2.1 Government documents

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-C-39028 - Capacitors, Packaging of, General Specification for

(See supplement 1 for list of associated specification sheets.)

STANDARDS

MILITARY

- MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.
- MIL-STD-690 - Failure Rate Sampling Plans and Procedures.
- MIL-STD-790 - Reliability Assurance Program for Electronic Parts Specifications.
- MIL-STD-810 - Environmental Test Methods and Engineering Guidelines.
- MIL-STD-1276 - Leads for Electronic Component Parts.
- MIL-STD-1285 - Marking of Electrical and Electronic Parts.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

- EIA-554 - Assessment of Outgoing Nonconforming Levels in Parts Per Million (PPM).
- EIA-557 - Statistical Process Control Systems.

(Application for copies should be addressed to the Electronic Industries Association, 2001 Eye Street, NW, Washington, DC 20006.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern (see 6.2).

3.2 Qualification. Capacitors furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list (QPL) at the time set for opening of bids (see 4.4 and 6.3). In addition, the manufacturer shall obtain certification from the qualifying activity that the reliability assurance requirements of 4.1.2 have been met and are being maintained. Authorized distributors which are approved to MIL-STD-790 distributor requirements by the QPL manufacturers are listed in the QPL.

3.3 Reliability and quality.

3.3.1 Reliability. Reliability of capacitors furnished under this specification shall be established and maintained in accordance with the procedures and requirements specified in MIL-STD-790 and MIL-STD-690 with details specified in 4.1.1, 4.4.4, and 4.5.

3.3.2 Quality.

3.3.2.1 Statistical process control (SPC). The contractor shall implement and use SPC techniques in the manufacturing process for parts covered by this specification. The SPC program shall be developed and maintained in accordance with all the requirements of EIA-557. The SPC program shall be documented and maintained as part of the overall reliability assurance program as specified in MIL-STD-790. The implementation of SPC shall be 12 months from the date of this specification. Processes for application of SPC techniques should include but are not limited to:

- a. Pre-assembly.
- b. Assembly.
- c. Encapsulation.
- d. Packaging.

3.3.2.2 Quality levels. The quality of lots that have been subjected to and passed the subgroup 1, 100 percent screening inspection of the group A inspection shall be established and maintained in accordance with 4.4.4.2 and EIA-554. Individual PPM defect level (i.e., PPM-2 and PPM-3) and an overall PPM defect level (i.e., PPM-5) shall be established based on the tests prescribed in the subgroup 2 tests of the group A inspections. The defect level for PPM-2 shall be less than 100 PPM. The implementation of PPM verification shall be 12 months from the date of this specification.

3.3.2.2.1 Noncompliance. The contractor shall notify the qualifying activity when the 100 PPM level is reached or exceeded for PPM-2. The contractor shall provide sufficient information to the qualifying activity documenting the causes of the problem and what corrective action is being taken. Failure to correct this problem shall be the basis for removal of the affected product from the QPL (see 4.4.4.2).

3.4 Materials. Materials shall be as specified herein. However, when a definite material is not specified, a material shall be used which will enable the capacitors to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.4.1 Insulating and sealing materials. Compounds and films used in the insulating and sealing of capacitors shall be chemically inactive with respect to the capacitor element. The material, either in state of original application or as a result of having aged, shall have no adverse effect on the performance of the capacitors.

3.5 Design and construction. Capacitors shall be of the design, construction, and physical dimensions specified (see 3.1).

3.5.1 Case. Each capacitor shall be enclosed in a nonmetal case which will protect the capacitor element from moisture, impregnant leakage, and mechanical damage under the test conditions specified herein. Cardboard shall not be used for insulating purposes.

3.5.2 Capacitor element. The capacitor element shall consist of foil or metallized conducting electrodes separated by one or more layers of dielectric film. Extended foil construction shall be used for characteristics K, M, Q, and S, and extended electrode construction for characteristics L, N, and R.

3.5.3 Terminals. Terminals shall be of a solid conductor, of the length and diameter specified (see 3.1), and shall be suitably treated to facilitate soldering. When a coating containing tin is used, the tin content shall range between 40 and 70 percent.

3.5.3.1 Solder dip (re-tinning) leads. Only the manufacturer (or his authorized category B or C distributor) may solder dip/re-tin the leads of product supplied to this specification provided the solder dip process has been approved by the qualifying activity.

3.5.3.2 Qualifying activity approval. Approval of the solder dip process will be based on one of the following options:

- a. When the original lead finish qualified was hot solder dip lead finish 52 of MIL-STD-1276 (Note: the 200 microinch maximum thickness is not applicable), the manufacturer shall use the same solder dip process for reflowing as is used in the original manufacture of the product.
- b. When the lead originally qualified was not hot solder dip lead finish 52 of MIL-STD-1276 as prescribed in 3.5.3.2a, approval for the process to be used for solder dip shall be based on the following test procedure:
 - (1) Thirty samples of any capacitance value for each style and lead finish are subjected to the manufacturing's solder dip process. Following the solder dip process, the capacitors are subject to the CAP, DF, IR, DWV, and ESR measurements (as applicable). No defects are allowed.
 - (2) Ten of the 30 samples are then subjected to the solderability test. No defects are allowed.
 - (3) The remaining 20 samples are subjected to the resistance to solder heat test. No defects are allowed. (Note: Solder dip of gold plated leads is not allowed.)

3.5.3.3 Solder dip/reflowing options. The manufacturer (or authorized category C distributor) may solder dip/reflow as follows:

- a. As a corrective action if the lot fails the group A solderability test.
- b. After the group A inspection has been completed, following the solder dip/reflowing process, the CAP, DF, IR, DWV, and ESR measurements (as applicable) shall be performed on 100 percent of the lot. The percent defective allowable (PDA) for the electrical measurements shall be as for the subgroup 1 tests. Following these tests, the manufacturer shall submit the lot to the group A solderability test as specified in 4.7.16.

3.6 Resistance to solvents. When capacitors are tested as specified in 4.7.2, markings shall remain legible, and shall not smear.

3.7 Preconditioning. When tested as specified in 4.7.3, capacitors shall withstand the test conditions specified without evidence of unwrapping of the capacitor case or sleeve or other damage to the case.

3.8 Burn-in (when specified, see 3.1). When tested as specified in 4.7.4, capacitors shall withstand the exposure to high temperature and overvoltages without visible damage.

3.9 Insulation resistance. When measured as specified in 4.7.5, unless otherwise specified (see 3.1), the insulation resistance shall be not less than the applicable value specified in table VI, and as shown on figure 1. The value of insulation resistance varies with temperature, and a correction factor obtained in accordance with table VII shall be applied, when necessary, by multiplying the value measured by the correction factor.

3.10 Dielectric withstanding voltage. When capacitors are tested as specified in 4.7.6, there shall be no momentary or intermittent arcing or other indication of breakdown, nor shall there be any visible evidence of damage.

3.11 Barometric pressure (reduced). When capacitors are tested as specified in 4.7.7, there shall be no momentary or intermittent arcing or other indication of breakdown, nor shall there be any visible evidence of damage.

TABLE VI. Insulation resistance.

Capacitance	Minimum insulation resistance (terminal to terminal)
<u>Characteristics K and L</u>	
	<u>At +25°C</u>
0 to .5 μ F	400,000 megohms
Greater than 1 μ F	200,000 megohm-microfarads <u>1/</u>
	<u>At +85°C</u>
0 to .5 μ F	20,000 megohms
Greater than 1 μ F	10,000 megohm-microfarads <u>1/</u>
	<u>At +105°C</u>
0 to .5 μ F	2,000 megohms
Greater than 1 μ F	1,000 megohm-microfarads <u>1/</u>
<u>Characteristic M</u>	
	<u>At +25°C</u>
0 to .1 μ F	500,000 megohms
Greater than .1 μ F	50,000 megohm-microfarads <u>1/</u>
	<u>At +85°C</u>
0 to .1 μ F	50,000 megohms
Greater than .1 μ F	5,000 megohm-microfarads <u>1/</u>
<u>Characteristic N</u>	
	<u>At +25°C</u>
0 to .25 μ F	200,000 megohms
Greater than .25 μ F	50,000 megohm-microfarads <u>1/</u>
	<u>At +85°C</u>
0 to .1 μ F	35,000 megohms
Greater than .1 μ F	3,500 megohm-microfarads <u>1/</u>
<u>Characteristic Q</u>	
	<u>At +25°C</u>
0 to .2 μ F	500,000 megohms
Greater than .2 μ F	100,000 megohm-microfarads <u>1/</u>
	<u>At +85°C</u>
0 to .1 μ F	100,000 megohms
Greater than .1 μ F	10,000 megohm-microfarads <u>1/</u>
	<u>At +125°C</u>
0 to .1 μ F	10,000 megohms
Greater than .1 μ F	1,000 megohm-microfarads <u>1/</u>

See footnote at end of table.

TABLE VI. Insulation resistance - Continued.

Capacitance	Minimum insulation resistance (terminal to terminal)
<u>Characteristic P</u>	
0 to .2 μ F Greater than .2 μ F	<u>At +25°C</u> 500,000 megohms 100,000 megohm-microfarads $\frac{1}{/}$
	<u>At +85°C</u> 70,000 megohms 7,000 megohm-microfarads $\frac{1}{/}$
0 to .1 μ F Greater than .1 μ F	<u>At +125°C</u> 7,000 megohms 700 megohm-microfarads $\frac{1}{/}$
<u>Characteristic S</u>	
0 to .2 μ F Greater than .2 μ F	<u>At +25°C</u> 500,000 megohms 100,000 megohm-microfarads $\frac{1}{/}$
	<u>At +85°C</u> 50,000 megohms 5,000 megohm-microfarads $\frac{1}{/}$
0 to .1 μ F Greater than .1 μ F	<u>At +125°C</u> 1,000 megohms 100 megohm-microfarads $\frac{1}{/}$

$\frac{1}{/}$ Product obtained by multiplying the capacitance (in μ F) by the measured insulation resistance (in megohms).

TABLE VII. Insulation resistance correction factors.

Correction factor	Temperature (°C)	Correction factor	Temperature (°C)
2.00	15	.94	26
1.87	16	.87	27
1.74	17	.82	28
1.62	18	.76	29
1.52	19	.71	30
1.42	20	.67	31
1.33	21	.63	32
1.24	22	.59	33
1.16	23	.55	34
1.08	24	.51	35
1.00	25		

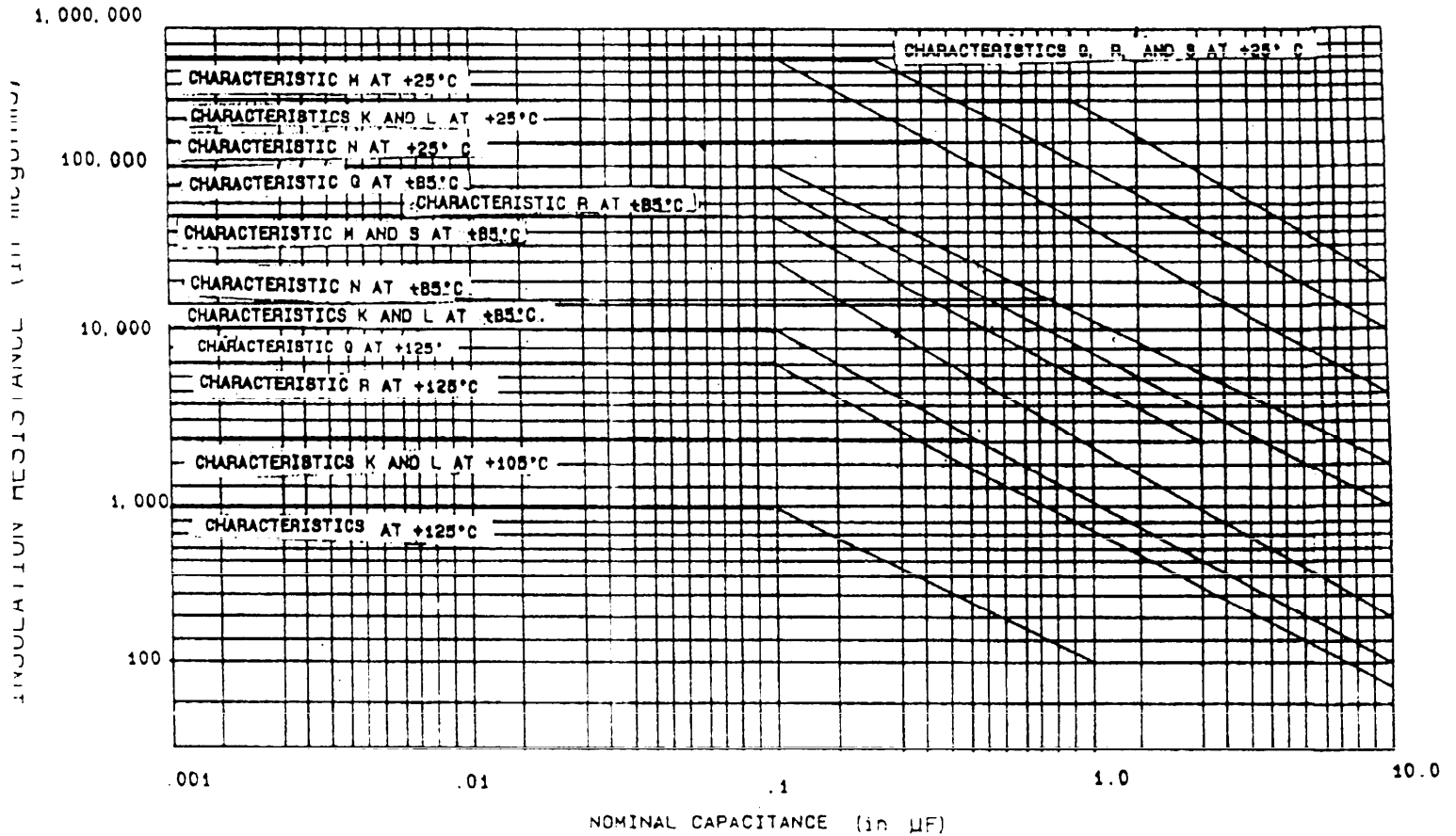


FIGURE 1. Graphical representation of minimum insulation resistance.

3.12 Capacitance. When measured as specified in 4.7.8, the capacitance shall be within the applicable tolerance specified (see 3.1).

3.13 Dissipation factor (all styles except CFR13, CFR14, CFR26, CFR27, and CFR29). When measured as specified in 4.7.9, the dissipation factor shall not exceed the applicable value specified in table VIII.

TABLE VIII. Dissipation factor.

Characteristic	Dissipation factor at			
	+25°C	+85°C	+105°C	+125°C
	%	%	%	%
K	0.1	0.1	0.1	
L	0.1	0.1	0.1	
M	0.75	0.85		
N	1.0	1.0		
Q	0.3	0.3		0.3
R	0.3	0.3		0.3
S	0.25	0.25		0.25

3.14 Equivalent series resistance (ESR) (applicable to styles CFR13, CFR14, CFR26, CFR27, and CFR29). When measured as specified in 4.7.10, the ESR (in ohms) shall not exceed the value specified (see 3.1).

3.15 Resistance to soldering heat. When tested as specified in 4.7.11, capacitors shall meet the following requirements:

Capacitance - - - - - Shall change not more than ± 5 percent from the initial measured value.

Dissipation factor (at +25°C) - - - Shall be as specified in 3.13.

3.16 Moisture resistance. When tested as specified in 4.7.12, capacitors shall meet the following requirements:

Dielectric withstanding voltage - - Shall be as specified in 3.10.

Insulation resistance (at +25°C):

Terminal to terminal - - - - - Shall be not less than 50 percent of the requirement specified in table VI.

Dissipation factor - - - - - Shall not exceed the requirements specified in table VIII.

Capacitance - - - - - (Characteristic S): Shall change not more than 0.5 percent from the initial measured value. (Characteristics K, L, M, N, Q, and R): Shall change not more than 5.0 percent from the initial measured value.

3.17 Vibration (high frequency). When capacitors are tested as specified in 4.7.13, there shall be no mechanical damage, momentary or intermittent arcing of 0.5 millisecond (ms) or greater duration, or other indication of breakdown, nor shall there be any open- or short-circuiting or visible mechanical damage.

3.18 Shock (specified pulse). When capacitors are tested as specified in 4.7.14, there shall be no momentary or intermittent arcing of 0.5 ms or greater duration, or other indication of breakdown, nor shall there be any evidence of fractures or other visible mechanical damage.

3.19 Terminal strength. When capacitors are tested as specified in 4.7.15, there shall be no mechanical damage to the capacitor or terminals.

3.20 Solderability. When capacitors are tested as specified in 4.7.16, the criteria for evaluation shall be as specified in method 206 of MIL-STD-202.

3.21 AC conditioning (when specified, see 3.1). When tested as specified in 4.7.17, capacitors shall withstand the ac voltage and current exposure without visible damage.

3.22 Low-temperature conditioning and capacitance change with temperature. When capacitors are tested as specified in 4.7.18, there shall be no indication of breakdown or arcing, nor shall there be any open- or short-circuiting or any visible evidence of mechanical damage. The capacitance shall change not more than the applicable values specified in table IX (the initial +25°C capacitance value (see 3.12) shall be used for determination of the capacitance change). In addition (for qualification testing only), the insulation resistance shall equal or exceed the minimum value specified in table VI for the high test temperature and the dissipation factor shall not exceed the applicable value for the high test temperature as specified in table VIII.

TABLE IX. Capacitance change with temperature.

Characteristic	Capacitance change (in percent) from +25°C value			
	-55°C	+85°C	+105°C	+125°C
K 1/	0 to +2.0	0 to -1.5	0 to -2.0	
L	0 to +2.0	0 to -2.5	0 to -3.5	
M	0 to -10.0	0 to +10.0		
N	0 to -10.0	0 to +10.0		
Q	0 to -2.5	±1.0		+2.0 to -1.0
R	0 to -2.5	±1.0		+2.0 to -1.0
S	0 to +2.0	0 to -2.0		0 to -4.0

1/ 800 volt units shall be at -55°C: 0 to +2.0; at +85°C: 0 to -2.5; at +105°C: 0 to -3.5.

3.23 Thermal shock. When tested as specified in 4.7.19, capacitors shall meet the following requirements:

- * Dielectric withstanding voltage - - - - - Shall be as specified in 3.10.
- Insulation resistance (at +25°C):
- Terminal to terminal - - - - - Shall be not less than 50 percent of the value specified in table VI.
- Visual examination - - - - - Shall show no visible deterioration, permanent damage to terminals or case, or corrosion on terminals.

3.24 Life. When tested as specified in 4.7.20, capacitors shall meet the following requirements:

- Insulation resistance (at +25°C) - - - - - Shall meet or exceed the initial requirement.
- Capacitance - - - - - Shall change not more than ±5 percent from the initial measured value (group I or subgroup 2).
- Dissipation factor (at +25°C) - - - - - Shall not exceed the value specified (see 3.13).

3.25 Fungus. The manufacturer shall certify that all external materials are fungus resistant or shall perform the test specified in 4.7.21. When capacitors are tested as specified in 4.7.21, examination shall disclose no evidence of fungus growth on the external surface.

3.26 Marking. Capacitors shall be permanently and legibly marked with the type designation, "JAN" or "J" marking, date code, and manufacturer's name, trademark, or code symbol. In the event the manufacturer's name, trademark, or code symbol exceeds two characters, it may appear on the next line. (Paper labels shall not be used.) Other markings which in any way interfere with, obscure, or confuse those specified herein are prohibited. Markings shall remain legible after all tests.

3.26.1 PIN (see 1.2.1). There shall be no space between the symbols which comprise the type designation. When the size of the capacitor does not permit the type designation to be marked on one line, it may be divided into two or three lines as shown in the following examples:

Examples:	CFR02AM		CFR02
	682JM	or	AMC
	J7011 TM		682JM
			J7011 TM

3.26.2 Date code. The date code shall be in accordance with MIL-STD-1285.

3.26.3 JAN and J marking. The United States Government has adopted, and is exercising legitimate control over the certification marks "JAN" and "J", respectively, to indicate that items so marked or identified are manufactured to, and meet all the requirements of military specifications. Accordingly, items acquired to, and meeting all of the criteria specified herein and in applicable specifications shall bear the certification mark "JAN" except that items too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be placed immediately before the PIN except that if such location would place a hardship on the manufacturer in connection with such marking, the "JAN" or "J" may be located on the first line above or below the PIN. Items furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein or in applicable specifications shall not bear "JAN" or "J". In the event an item fails to meet the requirements of this specification and the applicable specification sheets or associated detail specifications, the manufacturer shall remove the "JAN" or the "J" from the sample tested and also from all items represented by the sample. The "JAN" or "J" certification mark shall not be used on products acquired to contractor drawings or specifications. The United States Government has obtained Certificate of Registration Number 504,860 for the certification mark "JAN".

3.26.4 Supplying to higher failure rate levels. A manufacturer may supply to all higher failure rate levels than to which he is qualified. Parts qualified and marked to lower failure rate levels, with acquiring agency approval, are substitutable for higher failure rate levels, and shall not be remarked unless specified in the contract or acquisition document (see 6.2).

3.26.5 Supplying to looser capacitance tolerance and lower rated voltage. Parts qualified and marked to tighter capacitance tolerance or higher rated voltage, with acquiring agency approval, are substitutable for parts marked to looser capacitance tolerance or lower rated voltage, provided all other values, such as case size, characteristic, and leads are the same. The substitutable parts shall not be remarked unless specified in the contract or acquisition document (see 6.2).

3.27 Workmanship. Capacitors shall be processed in such a manner as to be uniform in quality and shall be free from pitted or corroded terminals, cracks, rough edges, and other defects that will affect life, serviceability, or appearance.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance (see 3.3.1). All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.1.2 Reliability assurance program (see 3.2). A reliability assurance program shall be established and maintained in accordance with MIL-STD-790; "Program implementation" exceptions are as follows:

- a. Under "Description of production processes and controls", the procedure for identification of each production lot shall include only "the manufacturer shall as a minimum be able to identify the time period during which the final production operation was performed on each item of product prior to final test. The date or lot code marked on each part shall be identified to a production lot."
- b. "Traceability" of materials shall not apply.

Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification.

4.1.3 Statistical process control (SPC). A SPC program shall be established and maintained in accordance with EIA-557. Evidence of such compliance shall be verified by the qualifying activity as a prerequisite for qualification and retention of qualification.

4.2 Classification of inspections. The inspections specified herein are classified as follows:

- a. Qualification inspection (see 4.4).
- b. Verification of qualification (see 4.5).
- c. Quality conformance inspection (see 4.6).

4.3 Inspection conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202.

4.3.1 Accuracy of voltage measurements. Accuracy of voltage measurements shall be within ± 2 percent of the specified voltage.

4.4 Qualification inspection (see 3.2). 1/ Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on sample units produced with equipment and procedures normally used in production.

4.4.1 Sample size. The number of capacitors to be subjected to qualification inspection shall be as specified in table X, or in the appendix to this specification.

4.4.2 Test routine. The sample shall be subjected to the inspections specified in table X, in the order shown. Except as specified below, all sample units shall be subjected to the inspections of group I (two sample units are to be subjected to the visual and mechanical examination, five sample units are to be subjected to the resistance to solvents examination, and the remaining sample units are to be subjected to the subsequent examinations of group I). The sample shall then be divided as specified in table X for group II through VI and subjected to the inspections for their particular group.

4.4.3 Failures. Failures in excess of those allowed in table X shall be cause for refusal to grant qualification approval.

1/ The decision as to whether or not the product is to be included on the QPL shall be made at the conclusion of the 2,000-hour life test.

TABLE X. Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected <u>1/</u>	Number of failures allowed <u>2/</u>
<u>Group I</u>				
Visual and mechanical examination (internal): Material, design, construction, and workmanship	3.1, 3.4 to 3.5.3, 3.26, and 3.27	4.7.1	2	0
Visual and mechanical examination (external) <u>3/</u> : Physical dimensions, marking, and workmanship <u>4/</u>	3.1, 3.5, 3.5.1, 3.5.3, 3.26, and 3.27	4.7.1	120	0
Resistance to solvents	3.6	4.7.2	5	0
Preconditioning	3.7	4.7.3		
Burn-in (when specified, see 3.1)	3.8	4.7.4		
Insulation resistance (at +25°C)	3.9	4.7.5	115	1
Dielectric withstanding voltage	3.10	4.7.6		
Barometric pressure (reduced)	3.11	4.7.7		
Capacitance	3.12	4.7.8		
Dissipation factor (at +25°C) <u>5/</u>	3.13	4.7.9		
Equivalent series resistance <u>6/</u>	3.14	4.7.10		
<u>Group II</u>				
Resistance to soldering heat	3.15	4.7.11	12	
Moisture resistance	3.16	4.7.12		
Vibration, high frequency	3.17	4.7.13		
Shock (specified pulse)	3.18	4.7.14		
Terminal strength	3.19	4.7.15		
<u>Group III</u>				
Solderability	3.20	4.7.16	6	0
AC conditioning (when specified, see 3.1)	3.21	4.7.17		
<u>Group IV</u>				
Low temperature conditioning and capacitance change with temperature	3.22	4.7.18	12	
Thermal shock and immersion	3.23	4.7.19		

See footnotes at end of table.

TABLE X. Qualification inspection - Continued.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected <u>1/</u>	Number of failures allowed <u>2/</u>
<u>Group V</u>				
Life (rated conditions)	3.24	4.7.20	50	} 1
Life (accelerated conditions)	3.24	4.7.20	30	
<u>Group VI</u>				
Fungus <u>7/</u>	3.25	4.7.21	4	0

1/ One additional sample unit is included in each sample size to permit substitution for the failure allowed in group I.

2/ A sample unit having one or more defects shall be considered as a single failure.

3/ Nondestructive examinations and tests.

4/ Marking defects are based on visual examination only and shall be charged only for illegible, incomplete, or incorrect marking.

5/ All styles except CFR13, CFR14, CFR26, CFR27, and CFR29.

6/ For styles CFR13, CFR14, CFR26, CFR27, and CFR29.

7/ Certification of fungus resistance may be substituted for testing.

4.4.4 Failure rate level and quality level verification.

4.4.4.1 Failure rate qualification (see 3.3.1). Failure rate (FR) qualification shall be in accordance with the general and detailed requirements of MIL-STD-690 and the following details:

- a. Procedure I - Qualification at the initial FR level. Level M (1.0 percent) of FRSP-90 shall apply. Sample units which have been subjected to rated conditions testing of the qualification inspection specified in group V, table X (see 4.4.2), shall be continued on test as specified in 4.7.20.3.
- b. Procedure II - Extension of qualification to lower FR levels. To extend qualification to the R (0.01 percent) and S (0.001 percent) FR levels, data from two or more voltage ratings within a style and characteristic may be combined.
- c. Procedure III - Maintenance of FR level qualification. Maintenance period B of FRSP-10 shall apply. Regardless of the number of production lots produced during this period, the specified number of unit hours shall be accumulated to maintain qualification.
- d. Procedure IV - Lot conformance FR inspection. Lot conformance FR procedures shall be in accordance with 4.6.2.1.1.3.

4.4.4.2 Quality level verification. The contractor is responsible for establishing a quality system to verify the PPM defect level of lots that are subjected to subgroup 2 tests of the group A inspections. The PPM defect level shall be maintained for each specification sheet. The PPM defect level shall be based on a 6-month moving average. The contractor shall verify and report individual PPM categories (i.e., PPM-2 and PPM-3) and an overall PPM defect level (i.e., PPM-5). In the event that the contractor meets or exceeds 100 PPM for PPM-2, the qualifying activity shall take the actions specified in 3.3.2.2.1.

4.5 Verification of qualification (see 3.3.1). Every 6 months, the manufacturer shall compile a summary of the results of quality conformance inspections and, where applicable, extended FR test data, in the form of a verification of qualification report, and forward it to the qualifying activity as the basis of continued qualification approval. In addition, within 30 days of the end of the reporting date, the manufacturer shall immediately notify the qualifying activity whenever the FR data indicates that the manufacturer has failed to maintain his qualified FR level. Continuation shall be based on evidence that, over the 6-month period, the following has been met:

- a. Verification by the qualifying activity that the manufacturer meets the requirements of MIL-STD-790.
- b. The manufacturer has not modified the design of the item.
- c. The specification requirements for the item have not been amended so as to affect the character of the item.
- d. Lot rejection for group A inspection does not exceed 10 percent or one lot, whichever is greater.
- e. The requirements for group B inspection are met.
- f. The records of all FR tests combined substantiate that the "M" (1.0 percent) or "P" (0.1 percent) FR level has been maintained, or that the manufacturer continues to meet the "R" (0.01 percent) and "S" (0.001 percent) FR level for which qualified, although the total component hours of testing does not, as yet, meet the requirements of 4.4.4.1c.
- g. The contractor shall provide documentation to the qualifying activity pertaining to PPM calculations including numbers of part types tested, individual PPM defect categories (i.e., PPM-2 and PPM-3) and the overall PPM defect rate (PPM-5). This information shall be submitted on a specification sheet basis.

If group B test requirements were not met and the manufacturer has taken corrective action satisfactory to the Government, the forwarding of the verification of qualification report may be delayed until within 30 days after completion of retesting of the group B inspections. In this case, the qualifying activity shall be notified of this condition within the time the original verification of qualification report was due. All reports shall be certified by a responsible company official. The qualifying activity shall be contacted for the report format.

4.5.1 Records. Maintenance of life test and FR level records shall be as specified in MIL-STD-690.

4.6 Qualify conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A inspection.

4.6.1.1 Inspection and production lot.

4.6.1.1.1 Inspection lot. An inspection lot shall consist of all capacitors from the same production line or lines, of the same style, rated voltage, dielectric material and offered for inspection during a single work month. Each lot shall be kept separate from every other lot. The sample selected from the lot shall be representative of the capacitance values and case sizes in the lot. Style CFR14 capacitors shall be considered their own lot. All sample units belonging to a lot shall be identified by means of a code symbol (either letters or numbers, at the option of the manufacturer).

4.6.1.1.2 Production lot. A production lot shall consist of capacitors of the same style, voltage rating, nominal capacitance value, and characteristic. Manufacture of all parts in the lot shall have been started, processed, assembled, and tested as a group. Lot identity shall be maintained throughout the manufacturing cycle.

4.6.1.2 Subgroup 1 tests. Subgroup 1 test shall be performed on a production lot basis on 100 percent of the product supplied under this specification. Capacitors failing the tests of subgroup 1 shall be removed from the lot. If during the 100 percent inspection, screening requires that more than 5 percent of the capacitors be discarded, the entire production lot shall be rejected.

4.6.1.2.1 Manufacturer's production inspection. If the manufacturer performs tests similar to those specified in subgroup 1, table XI, as the final step of the production process, group A, subgroup 1 inspection may be waived and the data resulting from the manufacturer's production tests may be used instead. Authority to waive the subgroup 1 inspection shall be granted by the qualifying activity only. The following criteria shall be complied with:

- a. Tests conducted by the manufacturer during production shall be clearly identical to or more stringent than that specified for subgroup 1. Tests conditions shall be equal to or more stringent than those specified for subgroup 1 tests.
- b. Manufacturer subjects 100 percent of the product supplied under this specification to the production tests.
- c. The parameters measured and the failure criteria shall be the same or more stringent than those specified herein.
- d. The lot rejection criteria are the same or more stringent than those specified herein.
- e. The manufacturer shall make available all information concerning the test procedures and instrumentation used in the production tests. The manufacturer shall also make available to the Government all records of all detail test data resulting from production tests.
- f. Once approved, the manufacturer shall not change the test procedures or criteria without prior notification and concurrence by the qualifying activity.

TABLE XI. Group A inspection.

Inspection	Requirement paragraph	Test method paragraph	Sample	Lot criteria
<u>Subgroup 1</u>				
Preconditioning	3.7	4.7.3	} 100 percent inspection	
Burn-in (when specified, see 3.1)	3.8	4.7.4		
Dielectric withstanding voltage	3.10	4.7.6		
Insulation resistance (at +25°C)	3.9	4.7.5		
Capacitance	3.12	4.7.8		
Dissipation factor (at +25°C)	3.13	4.7.9		
Equivalent series resistance (at +25°C) 1/	3.14	4.7.10		

TABLE XI. Group A inspection - Continued.

Inspection	Requirement paragraph	Test method paragraph	Sample	Lot criteria
<u>Subgroup 2 (PPM)</u>				
Dielectric withstanding voltage (PPM-2)	3.10	4.7.6	} See table XII	} Reject one defect
Insulation resistance (at +25°C) (PPM-2)	3.9	4.7.5		
Capacitance (PPM-2)	3.12	4.7.8		
Dissipation factor (at +25°C) (PPM-2)	3.13	4.7.9		
Equivalent series resistance (at +25°C) (PPM-2) 1/	3.14	4.7.10	} 13	} 0
Mechanical examination external (PPM-3)	3.4	4.7.1		
<u>Subgroup 3</u>				
Visual inspection:			} 13	} 0
Physical dimensions	3.1	4.7.1		
Marking 2/	3.25	4.7.1		
<u>Subgroup 4</u>				
Insulation resistance (at high operating temperature)	3.9	4.7.5	} 13	} 0
Dissipation factor (at high operating temperature)	3.13	4.7.9		
Equivalent series resistance (at high operating temperature) 1/	3.14	4.7.10		
Barometric pressure (reduced)	3.11	4.7.7		
<u>Subgroup 5</u>				
Solderability	3.20	4.7.16	13	0

^{1/} For information purposes only.

^{2/} Marking defects are based on visual inspection and shall be charged only for illegible, incomplete, or incorrect marking. Any subsequent electrical defects shall not be used as a basis for determining marking defects.

4.6.1.3 Subgroup 2 tests (PPM categories).

4.6.1.3.1 Sampling plans. Subgroup 2 tests shall be performed on an inspection lot basis. Samples subjected to subgroup 2 shall be selected in accordance with table XII, based on the size of the inspection lot. In the event of one or more failures, the lot shall be rejected. Equipment and operators used to perform the subgroup 2 tests shall not be the same as those used in the subgroup 1, 100 percent tests.

4.6.1.3.2 Rejected lots. The rejected lot shall be segregated from new lots and those lots that have passed inspection. The rejected lot shall be 100 percent inspected for those quality characteristics found defective in the sample and any defectives found removed from the lot. A new sample of parts shall then be randomly selected in accordance with table XII. If one or more defects are found in this second sample, the lot shall be rejected and shall not be supplied to this specification.

4.6.1.3.3 PPM calculations. PPM calculation shall be based on the results of the first sample check as prescribed in 4.6.1.3.1. Calculations and data exclusion shall be in accordance with EIA-554. (Note: PPM calculations shall not use data on the second sample submission.)

TABLE XII. Sampling plans for PPM categories.

Lot size	Sample size
1 - 125	100 percent
126 - 3,200	125
3,201 - 10,000	200
10,001 - 35,000	315
35,001 - 150,000	500
150,001 - 500,000	800
500,001 - up	1,250

4.6.1.4 Subgroups 3 and 4 tests. Subgroups 3 and 4 shall be performed on an inspection lot basis. The sampling procedures shall be as specified in table XI.

4.6.1.4.1 Rejected lots. The rejected lots shall be segregated from new lots and those lots that have passed inspection. Lots rejected because of failures in subgroup 3 or 4 may be offered for inspection only if the manufacturer inspects all units in the lot for those quality characteristics found defective in the sample and, after removing all defects, reinspects the lot using the sampling procedure specified in table XI. If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification. Resubmitted lots shall be kept separate from new lots, and shall be identified as resubmitted lots.

4.6.1.5 Subgroup 5 tests (solderability), styles CFR26 and CFR27 not applicable.

4.6.1.5.1 Sampling plan. Thirteen samples shall be selected randomly from each inspection lot and subjected to the solderability test. The manufacturer may use electrical rejects from the subgroup 1 screening tests for all or part of the samples to be used for solderability testing. If there are one or more defects, the lot shall be rejected.

4.6.1.5.2 Rejected lots. In the event of one or more defects, the inspection lot is rejected. The manufacturer may use one of the following options to rework the lot:

- a. Each production lot that was used to form the failed inspection lot shall be individually submitted to the solderability test as required in 4.6.1.5.1. Production lots that pass the solderability test are available for shipment. Production lots failing the solderability test can be reworked only if submitted to the solder dip procedure in 4.6.1.5.2b.
- b. The manufacturer submits the failed lot to a 100 percent solder dip using an approved solder dip process in accordance with 3.5.3.1. Following the solder dip, the electrical measurements required in group A, subgroup 1 tests shall be repeated on 100 percent of the lot. The PDA for the electrical measurements shall be as for the subgroup 1 tests. Thirteen additional samples shall be then selected and subjected to the solderability test with zero defects allowed. If the lot fails this solderability test, the lot shall be considered rejected and shall not be furnished against the requirements of this specification.

4.6.1.5.3 Disposition of samples. The solderability test is considered a destructive test, and samples submitted to the solderability test shall not be supplied on the contract.

4.6.2 Periodic inspection. Periodic inspection shall consist of group B inspection. Except where the results of this inspection show noncompliance with the applicable requirements (see 4.6.2.1.1.4), delivery of products which have passed group A inspection shall not be delayed pending the results of group B inspection.

4.6.2.1 Group B inspection. Group B inspection shall consist of the tests specified in table XIII, in the order shown, and shall be performed on sample units selected from lots that have passed group A inspection. Test data obtained therefrom shall be reviewed as a part of the complete verification of qualification. Maximum and minimum case sizes shall be represented, as far as practical, in at least the approximate ratio of production.

4.6.2.1.1 Sampling plan.

4.6.2.1.1.1 Subgroups 1 and 1B (all FR levels). Six (characteristics M and N) or sixteen (characteristics K, L, Q, R, and S) sample units shall be taken from production every 3 months and subjected to the applicable tests for their particular subgroup. Allowable failures shall be as specified in table XIII.

4.6.2.1.1.2 Subgroup 2 and 2A (all FR levels). Seventeen sample unit shall be taken from production every 6 months and subjected to the applicable tests for their particular subgroup. Allowable failures shall be as specified in table XIII.

4.6.2.1.1.3 Subgroup 1A (all FR levels) A minimum of 10 sample units shall be selected from each inspection lot produced during a 1-month period. Allowable failures shall be as specified in MIL-STD-690. The accumulated data shall be used for maintenance and extension of FR qualification.

TABLE XIII. Group B inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of failures allowed ^{1/}
<u>Subgroup 1 (every 3 months)</u>				
Low temperature conditioning and capacitance change with temperature	3.22	4.7.18	6	1
Thermal shock and immersion	3.23	4.7.19		
<u>Subgroup 1A (every month)</u>				
Life (at accelerated conditions)	3.24	4.7.20	10 minimum	
<u>Subgroup 1B (every 3 months) 2/ 3/</u>				
Life at +125°C (proof test) characteristics K, L, Q, R, and S	3.24	4.7.20.3.2	10	1
<u>Subgroup 1C (every 3 months)</u>				
AC conditioning (when specified, see 3.1)	3.21	4.7.17	(See 3.1)	5 percent
<u>Subgroup 2 (every 6 months)</u>				
Resistance to soldering heat	3.15	4.7.11	12	0
Moisture resistance	3.16	4.7.12		
Vibration, high frequency	3.17	4.7.13		
Shock (specified pulse)	3.18	4.7.14		
Terminal strength	3.19	4.7.15		
<u>Subgroup 2A (every 6 months)</u>				
Resistance to solvents	3.6	4.7.2	5	0

^{1/} A sample unit having one or more defects shall be considered as a single failure.

^{2/} Proof test data is not used in FR level determination.

^{3/} Life at +125°C (proof test) for characteristics K and L.

4.6.2.1.1.4 Disposition of sample units. Sample units which have been subjected to group B inspection shall not be delivered on the contract.

4.6.2.1.1.5 Noncompliance. If a sample fails to pass group B inspection, the manufacturer shall notify the qualifying activity and the cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance and shipment of the product shall be discontinued until corrective action, acceptable to the qualifying activity has been taken. After the corrective action has been taken, group B inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed, at the option of the qualifying activity). Group A inspection may be reinstituted; however, final acceptance and shipment shall be withheld until the group B inspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure shall be furnished to the cognizant inspection activity and the qualifying activity.

4.6.3 Inspection of preparation for delivery. Sample packages and packs and the inspection of the preservation and packaging, packing, and marking for shipment and storage shall be in accordance with the requirements of MIL-C-39028.

4.7 Methods of inspection.

4.7.1 Visual and mechanical examination. Capacitors shall be examined to verify that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.4, 3.5, 3.26, and 3.27).

4.7.2 Resistance to solvents (see 3.6). Capacitors shall be tested in accordance with method 215 of MIL-STD-202. The following exceptions shall apply:

- a. Brushing is not required.
- b. Solvent solution (b) Trichloroethane.

4.7.3 Preconditioning (see 3.7). Capacitors shall be exposed to a saturated steam atmosphere of 5 lb_f/in² (gauge pressure) for a period of 90 minutes. The terminals shall not be welded, soldered, or disfigured to perform the seal part of this test. Capacitors shall be examined for unwrapping of case material or other damage to the case.

4.7.4 Burn-in (when specified, see 3.1) (see 3.8). Capacitors shall be tested as follows:

- a. DC: 140 percent of dc rated voltage shall be applied for 48 hours, minimum at +125°C +4, -0°C.
- b. AC: 140 percent of rated RMS voltage shall be applied for 16 hours, minimum at +125°C +4, -0°C and 400 ±10 Hz.

4.7.5 Insulation resistance (see 3.9). Capacitors shall be tested in accordance with method 302 of MIL-STD-202. The following details shall apply:

- a. Test potential: Equal to rated voltage (or derated voltage if applicable), or 500 volts, dc, whichever is less (see 3.1).
- b. Points of measurement: Terminal to terminal.
- c. Electrification time: Two minutes maximum; however, for capacitance values greater than 1 µF an additional 1 minute per µF is permitted.

4.7.6 Dielectric withstanding voltage (see 3.10). Capacitors shall be tested in accordance with method 301 of MIL-STD-202. The following details and exception shall apply:

- a. Magnitude and duration of test voltage: 200 percent of rated voltage for 10 to 60 seconds.
- b. Nature of potential: dc.

- c. Points of application of test voltage: Between terminals.
- d. Limiting value of surge current: Shall not exceed 50 milliamperes (mA).
- e. Examination after test: Capacitors shall be examined for evidence of damage, arcing, or breakdown.

4.7.7 Barometric pressure (reduced) (see 3.11). Capacitors shall be tested in accordance with method 105 of MIL-STD-202. The following details shall apply:

- a. Method of mounting: Normal mounting means.
- b. Test condition: D (100,000 feet).
- c. Test during subjection to reduced pressure: 150 percent of rated voltage (characteristics M, Q, and S), or 140 percent of rated voltage (characteristics K, L, N, and R) shall be applied between the terminals for not less than 1 minute.
- d. Examination after test: Capacitors shall be visually examined for evidence of damage.

4.7.8 Capacitance (see 3.12). Capacitance shall be measured in accordance with method 305 of MIL-STD-202. The following details shall apply:

- a. Test frequency: 1 kilohertz (kHz) = 100 hertz (Hz).
- b. Limit of accuracy: Within ± 0.5 percent.

4.7.9 Dissipation factor (all styles except CFR13, CFR14, CFR26, CFR27, and CFR29) (see 3.13). The dissipation factor shall be measured at an ac voltage not greater than 20 percent of the rated voltage (or 10 volts, whichever is less (see 3.1)), at a frequency of 1 kHz = 100 Hz. Measurement accuracy shall be within ± 2 percent.

4.7.10 Equivalent series resistance (ESR) applicable to styles CFR13, CFR14, CFR26, CFR27, and CFR29 (see 3.14). ESR shall be determined by a suitable measuring device. Instrument measurement accuracy shall be within ± 2 percent. AC measurements shall be made at a frequency of 100 kHz ± 10 percent. ESR is to be measured within .250 (6.35 mm) to .500 inch (12.70 mm) of case.

4.7.11 Resistance to soldering heat (see 3.15). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details shall apply:

- a. Depth of immersion in molten solder: Within .250 inch (6.35 mm) of the seal or case.
- b. Test condition: G.
- c. Cooling time prior to measurement after test: 10 ± 1 minutes.
- d. Measurement after test: Capacitance and dissipation factor at +25°C shall be measured as specified in 4.7.8 and 4.7.9 respectively.

4.7.12 Moisture resistance (see 3.16). Capacitors shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

- a. Mounting: Capacitors shall be mounted by their normal mounting means. Except during measurements, the terminals shall be secured .500 \pm .125 inch from point of egress to test jig.
- b. Initial measurements: Not applicable.
- c. Number of cycles: 20.
- d. Polarization voltage: During steps 1 to 6 inclusive, a dc potential of 100 volts or rated voltage, whichever is less (see 3.1), shall be applied across the terminals of 50 percent of the capacitors. No potential shall be applied to the remaining 50 percent of the capacitors.

e. Loading voltage: Not applicable.

f. Final measurements: After the final cycle, capacitors shall be conditioned at $+25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ at a relative humidity of 50 ± 5 percent for a period of at least 22 hours, but not more than 24 hours. Dielectric withstanding voltage, insulation resistance, dissipation factor, and capacitance shall be measured at $+25^{\circ}\text{C}$ as specified in 4.7.6, 4.7.5, 4.7.9, and 4.7.8 respectively.

4.7.13 Vibration, high frequency (see 3.17). Capacitors shall be tested in accordance with method 204 of MIL-STD-202. The following details and exceptions shall apply:

- a. Mounting of specimens: Securely fastened so that the body is restrained from movement. The terminals shall be soldered to rigidly supported stud-terminals, so spaced that the length of each terminal from the capacitor body to the edge of the supporting stud-terminal is .500 (12.70 mm) \pm .125 inch (\pm 3.18 mm).
- b. Electrical-load conditions: During the test, rated voltage (see 3.1) shall be applied between the terminals of the capacitor.
- c. Test condition: D (20 G's).
- d. Direction and duration of motion: Unless otherwise specified (see 3.1), 4 hours in each of two mutually perpendicular directions (total 8 hours), one parallel and the other perpendicular to the cylindrical axis.
- e. Measurements during vibration: During the last cycle in each direction, an electrical measurement shall be made to detect intermittent contacts of 0.5 ms or greater duration or open- or short-circuiting.
- f. Examination after test: While still mounted on the vibration jig, capacitors shall be visually examined for evidence of mechanical damage.

4.7.14 Shock (specified pulse) (see 3.18). Capacitors shall be tested in accordance with method 213 of MIL-STD-202. The following details and exception shall apply:

- a. Mounting: Rigidly mounted by the body.
- b. Test condition: I (100 G's pk).
- c. Electrical loading during shock: During the test, 125 percent of rated voltage (see 3.1) shall be applied between the terminals of the capacitor.
- d. Measurements during shock: During the test, a cathode-ray oscilloscope or other comparable means capable of detecting intermittent contacts of 0.5 ms duration or greater shall be used as an indicating device in determining any electrical failures.
- e. Examination after test: Capacitors shall be visually examined for evidence of breakdown, arcing, fractures, or any other visible mechanical damage.

4.7.15 Terminal strength (see 3.19). Capacitors shall be tested in accordance with method 211 of MIL-STD-202. The following details and exceptions shall apply:

- a. Test condition: A (axial and radial), 5 pounds; C (radial only), 5 pounds; and D (axial only).
- b. Test condition: A (lugs), 10 pounds for 1 minute.

4.7.16 Solderability (see 3.20). Capacitors shall be tested in accordance with method 208 of MIL-STD-202. The following details shall apply (see 3.5.3.3):

- a. The number of terminations of each capacitor to be tested: Two.
- b. Depth of immersion in flux and solder: Both terminals shall be immersed to within .125 inch (3.18 mm) of the capacitor body.
- c. No physical damage after test.

4.7.17 AC conditioning (when specified, see 3.1) (see 3.21). Capacitors shall be exposed to the voltages, currents, frequencies, and temperature specified (see 3.1) for 240 +48, -0 hours

4.7.18 Low-temperature conditioning and capacitance change with temperature (see 3.22).

4.7.18.1 Low-temperature conditioning. Capacitors shall be placed in a chamber maintained at $-55^{\circ}\text{C} \pm 3^{\circ}\text{C}$. Rated voltage (see 3.1), shall be applied at this condition for 48 \pm 4 hours. The air within the conditioning chamber shall be circulated.

4.7.18.2 Capacitance change with temperature. Capacitance shall be measured as specified in 4.7.8, at the temperatures and in the order shown in table XIV.

TABLE XIV. Capacitance measurements.

Step	Temperature
1	$-55^{\circ}\text{C} \pm 3^{\circ}\text{C}$
2	$+25^{\circ}\text{C} \pm 5^{\circ}\text{C}$
3	$+85^{\circ}\text{C} \pm 3^{\circ}\text{C}$
4	$+105^{\circ}\text{C} \pm 3^{\circ}\text{C}$
5	$+125^{\circ}\text{C} \pm 3^{\circ}\text{C}$ 1/ 2/
6	$+25^{\circ}\text{C} \pm 5^{\circ}\text{C}$

1/ Not applicable to characteristics K, L, M, and N capacitors.

2/ When measuring insulation resistance at $+125^{\circ}\text{C}$, the applicable derated voltage shall be used (see 3.1).

NOTE: The capacitance measurement at each temperature shall be recorded when two successive readings, taken at 5-minute intervals, indicate no change in capacitance.

In addition (for qualification testing only), insulation resistance and dissipation factor shall be measured at high test temperature(s) (steps 3 and 4 of table XIV), as specified in 4.7.5 and 4.7.9 respectively. Capacitors shall then be visually examined for evidence of breakdown, arcing, and other visible mechanical damage.

4.7.19 Thermal shock and immersion (see 3.23).

4.7.19.1 Thermal shock. Capacitors shall be tested in accordance with method 107 of MIL-STD-202. The following details shall apply:

- a. Test condition: A, except that during step 3, capacitors shall be conditioned at high operating temperature (see 3.1).
- b. Measurements before and after cycling: Not applicable.

4.7.19.2 Immersion. Within 4 to 24 hours after completion of temperature cycling, capacitors shall be tested in accordance with method 104 of MIL-STD-202. The following details shall apply:

- a. Test condition: B.
- b. Measurement after final cycle: Dielectric withstanding voltage and insulation resistance at +25°C shall be measured as specified in 4.7.6 and 4.7.5 respectively.

4.7.20 Life (see 3.24).

4.7.20.1 2,000-hour (qualification inspection). Capacitors shall be tested in accordance with method 108 of MIL-STD-202. The following details and exceptions shall apply:

- a. Method of mounting and distance between specimens: Rigidly mounted by the body with a distance of not less than 1-inch separation between units.
- b. Test temperature and tolerance: +85°C +4°C, -0°C.
- c. Operating conditions: Characteristics K, M, Q, and S capacitors shall be subjected to 140 percent of the +85°C dc rated voltage; characteristics L, N, and R capacitors shall be subjected to 125 percent of the +85°C dc rated voltage.

The surge current shall be limited to 1 ampere. When necessary, a suitable current-limiting resistor shall be inserted into the circuit. Means shall be provided to assure that the full required voltage is applied to the capacitor when current-limiting resistors are used. Radiation shall not be used as a means of heating the chamber.

- d. Test condition: F (2,000 +72, -0 hours).
- e. Measurements after exposure: Capacitors shall be returned to the inspection conditions specified in 4.3, and shall be visually examined for deformation of body, obliteration of markings, and leakage of filling compound, when applicable. Insulation resistance (at +25°C), capacitance, and dissipation factor (at +25°C), shall then be measured as specified in 4.7.5, 4.7.8, and 4.7.9 respectively.

4.7.20.2 2,000-hour (group B inspection) (see 3.24). Except as specified in the following, capacitors shall be tested as specified in 4.7.20.1: Test duration: 2,000 +72, -0 hours at accelerated conditions only.

4.7.20.3 Extended life (see 3.24).

4.7.20.3.1 Following 2,000-hour qualification test. Capacitors tested under rated conditions shall be continued on test for an additional 8,000 +96, -0 hours; measurements during and after exposure shall be accomplished after 2,000 +96, -0 hours and every 2,000 +96, -0 hours thereafter until a combined total of 10,000 +96, -0 hours have elapsed.

4.7.20.3.2 +125°C proof test. Except as specified in the following, capacitors shall be tested as specified in 4.7.20.1:

- a. Test temperature and tolerance: +125°C +4°C, -0°C.
- b. Operating conditions: Characteristic R capacitors shall be subjected to 125 percent of the derated voltage (see table III, footnote 1/). Characteristics Q and S capacitors shall be subjected to 140 percent of the derated voltage (see table III, footnote 1/).

4.7.21 Fungus (see 3.25). Capacitors shall be tested in accordance with method 508 of MIL-STD-810.

5. PACKAGING

5.1 Packaging requirements. The requirements for packaging shall be in accordance with MIL-C-39028.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Retinning. If retinning (hot solder dip) of the leads is required, see 3.5.3.1.

6.2 Acquisition requirements. Acquisition documents must specify the following:

- a. Title, number, and date of this specification.
- b. Issue of DDSS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1).
- c. Title, number, and date of the applicable specification sheet, and the complete type designation (see 3.1).
- d. Required levels of preservation and packaging and packing, and special marking (see section 5).
- e. Marking requirement for failure rate level (see 3.26.4).
- f. Marking requirements for tolerance and rated voltage levels (see 3.26.5).

6.3 Qualification (see 3.2). With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in the applicable QPL, whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts for the products covered by this specification. The activity responsible for the QPL is U.S. Army Laboratory Command (LABCOM), ATTN: SLGET-R-S, Fort Monmouth, NJ 07703-5302; however, information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-E), Dayton, OH 45444. Application for qualification tests shall be made in accordance with SD-6, "Provisions Governing Qualification" (see 6.3.1).

6.3.1 Provisions Governing Qualification. Copies of "Provisions Governing Qualification" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, Standardization Documents Order Desk, Building 40, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

6.4 Application information. Capacitors acquired under provisions of this specification will experience failure at a rate depending almost exclusively upon the manner in which the capacitors are used. For military applications, in view of their limited long term moisture resistant characteristics, these capacitors should be used in potted or encapsulated circuit packaging systems. ^{2/} In any case, the acquiring activity should review the specific application. Where the capacitors are not incorporated in an encapsulated or potted circuit package, hermetically sealed foil capacitors of MIL-C-19978 or hermetically sealed metallized capacitors of MIL-C-39022 or MIL-C-83421 are recommended. In addition, the life of the capacitors specified herein is primarily dependent upon the operating temperature and applied voltage. They should not be used above rated voltage or temperature.

6.4.1 Mounting. Capacitors covered by this specification should be mounted by a bracket or clamp, or they should be potted when vibration or shock are likely to be encountered in service. When a bracket or clamp is used, care should be taken to assure that the capacitor body is not deformed.

^{2/} For Navy use, these units shall only be used in potted or encapsulated circuit packaging systems.

6.5 Interchangeability. Capacitors specified as style CTM, characteristic V of MIL-C-27267/1 (USAF) are directly replaceable by style CFR02AM of MIL-C-55514/1A in the same +85°C voltage rating, capacitance value, tolerance, and in FRL-M.

NOTE. Even though style CTM units are voltage derated to +125°C, and style CFR02 units are rated only to +85°C, units are unilaterally interchangeable.

6.6 PIN. The PIN should be structured in accordance with 1.2.1.

6.7 Subject term (key word) Listing.

Capacitance

6.8 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

APPENDIX

QUALIFICATION-SUBMITTAL PLANS

10. SCOPE

10.1 Scope. This appendix details the qualification-submittal plans for capacitors to be subjected to the qualification inspection specified in this specification. These plans specify the sample size, sampling criteria, and limits of coverage for the type of qualification sought. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance only.

20. SUBMISSION

20.1 Sample single-type. The following details shall apply:

- a. Sample size: 122.
- b. Sampling criteria: Sample units of the same style, rated voltage, terminal, characteristic, capacitance, and capacitance tolerance.
- c. Limits of coverage: Qualification coverage will be limited to the type submitted.

20.1.2 Single-voltage. The following details apply:

- a. Sample size: 122.
- b. Sampling criteria: Sample units of the same style, same characteristic, highest capacitance, tightest tolerance, and same voltage rating. 3/ 4/
- c. Limits of coverage: Qualification coverage will be extended to all lower capacitance values and broader tolerances in the style, characteristic, and voltage rating represented.

20.1.3 Combined voltage. The following details apply:

- a. Sample size and voltage: 122 (61 each of any two adjacent voltages).
- b. Sampling criteria: Sample units of the same style, characteristic, highest capacitance, and lowest tolerance. 3/ 4/
- c. Limits of coverage: Qualification coverage will be extended to all lower capacitance values and broader tolerances in the style, characteristic, and both voltage ratings represented.

20.1.4 Complete style. For complete style, submission shall be in accordance with table XV.

30. DATA REQUIREMENTS

30.1 Description of items. The contractor shall submit a detailed description of the materials and constructional features of the capacitors being subjected to qualification inspection, including information as to whether they are impregnated or filled, the type and quantity of the impregnant or filling compound; the type, thickness, and the number of layers of plastic film and foil or metallization; the material, thickness, and applied finish of the case, as well as details on the end seal and terminal assembly.

30.2 Certification of materials. The contractor shall submit certification, in duplicate, that the materials used in their components are in accordance with the applicable specification requirements.

3/ Styles with more than one characteristic available will require separate submission for each characteristic.

4/ (Note: When axial and radial terminals apply to the same sample group, capacitors shall be divided equally between the two terminals types.)

APPENDIX

TABLE XV. Qualification samples.

Style	Type designation	Sample size
CFR02	CFR02AMB105GM	61
	CFR02AMC105GM	61
	CFR02AME105GM	61
	CFR02ANF104GM	61
	CFR02AQB105FM	61
	CFR02AQC105FM	61
CFR04	CFR04AMC104GM	61
	CFR04RME104GM	61
	CFR04AQB104FM	61
	CFR04RQC104FM	61
	CFR04AQE104FM	122
	CFR04ASA105FM	61
	CFR04RSA105FM	61
CFR05	CFR05ARA506FM	61
	CFR05ARB206FM	61
	CFR05ARC106FM	61
	CFR05ARE505FM	61
CFR06	CFR06ARA506FM	61
	CFR06RRB206FM	61
	CFR06ANC106FM	61
	CFR06RNE335FM	61
CFR09	CFR09ARA186FM	61
	CFR09ARB106FM	61
	CFR09ARH505FM	61
	CFR09ARC395FM	61
CFR12	CFR12RRA563GM	61
	CFR12RRG273GM	61
	CFR12RRH822GM	61
	CFR12RRK332GM	61
CFR13	CFR13ALB306JM	61
	CFR13ALC206JM	61
	CFR13ALE106JM	122
CFR14	CFR14LLB306JM	61
	CFR14LLC206JM	61
	CFR14LLE106JM	122
CFR15	CFR15AKC105JM	61
	CFR15AKE105JM	61
	CFR15AKF105JM	61
	CFR15AKL564JM	61
CFR16	CFR16RRA683GM	61
	CFR16RRA184GM	61
	CFR16RRA224GM	61
	CFR16RRA105GM	61

APPENDIX

TABLE XV. Qualification samples - Continued.

Style	Type designation	Sample size
CFR26 CFR27	^{1/} CFR2-LRA106JM	61
	CFR2-LRA506JM	61
	CFR2-LRG505JM	61
	CFR2-LRG506JM	61
	CFR2-LRB505JM	61
	CFR2-LRB506JM	61
CFR29	CFR29RRA106JM	61
	CFR29RRA506JM	61
	CFR29RRG305JM	61
	CFR29RRG506JM	61
	CFR29RRB305JM	61
	CFR29RRB506JM	61

^{1/} The complete type designation shall include a "6" or "7" for styles CFR26 or CFR27.

CONCLUDING MATERIAL

Custodians:

Army - ER
Navy - EC
Air Force - 85

Review activities:

Navy - 05
Air Force - 17, 99
DLA - ES

User activities:

Navy - AS, MC
Air Force - 19

Preparing activity:

Army - ER

Agent:

DLA - ES

(Project 5910-1690)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	MIL-C-55514C	920331
3. DOCUMENT TITLE Military Specification Capacitors, Fixed, Plastic (or Metallized Plastic) Dielectric, DC or DC-AC, in Nonmetal Cases, Established Reliability General Specification For		
4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)		

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code)	7. DATE SUBMITTED (YYMMDD)
	(1) Commercial (2) AUTOVON (if applicable)	

8. PREPARING ACTIVITY

a. NAME Commander LAPCOM	b. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (908) 544-3148 995-3148
c. ADDRESS (Include Zip Code) Attn: SLCET-RS Fort Monmouth, NJ 07701	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289 2340